Photometric Studies of Orbital Debris at GEO

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We report on optical observations of debris at geosynchronous Earth orbit (GEO) using two telescopes simultaneously at the Cerro Tololo Inter-American Observatory (CTIO) in Chile.

The University of Michigan's 0.6/0.9-m Schmidt telescope **MODEST** (for **M**ichigan **O**rbital **DE**bris **S**urvey **T**elescope) was used in survey mode to find objects that potentially could be at GEO. Because GEO objects only appear in this telescope's field of view for an average of 5 minutes, a full six-parameter orbit can not be determined. Interrupting the survey for follow-up observations leads to incompleteness in the survey results. Instead, as objects are detected with **MODEST,** initial predictions assuming a circular orbit are done for where the object will be for the next hour, and the objects are reacquired as quickly as possible on the CTIO 0.9-m telescope. This second telescope follows-up during the first night and, if possible, over several more nights to obtain the maximum time arc possible, and the best six parameter orbit.

Our goal is to obtain an initial orbit and calibrated colors for *all* detected objects fainter than R = 15^{th} in order to estimate the orbital distribution of objects selected on the basis of two observational criteria: magnitude and angular rate. One objective is to estimate what fraction of objects selected on the basis of angular rate are not at GEO. A second objective is to obtain magnitudes and colors in standard astronomical filters (BVRI) for comparison with reflectance spectra of likely spacecraft materials.

We will report on calibrated BVRI magnitudes and colors for a sample of more than 30 objects observed with the CTIO 0.9-m. Almost all objects are redder than solar in B-R, but show a broad distribution in R-I. The width of the color distribution may be intrinsic to the nature of the surfaces, but also could be due to the circumstance that we are seeing irregularly shaped objects and measuring the colors at different times with just one telescope.

For a smaller sample of objects we have observed with two telescopes simultaneously in different filters. The CTIO 0.9-m observes in B, and MODEST in R. The CCD cameras are electronically linked together so that the start time and duration of observations are the same to better than 50 milliseconds. Thus the B-R color is a true measure of the surface of the debris piece facing the telescopes for that observation. Any change in color reflects a real change in the debris surface.

We will compare our observations with models and laboratory measurements of selected surfaces.

This work is supported by NASA's Orbital Debris Program Office, Johnson Space Center, Houston, Texas, USA.